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Manuel Artís, Javier Romaní, Jordi Suriñach
Grup d'Anàlisi Quantitativa Regional. Universitat de Barcelona
Avda. Diagonal, 690 - 08034 Barcelona (Spain)
romani@eco.ub.es, surinach@eco.ub.es

COMMUTING IN CATALONIA: ESTIMATES FROM A PLACE-TO-PLACE MODEL

ABSTRACT: Which variables influence a zone's role as an attraction pole or a residential zone? In previous papers (presented to the ERSA and Spanish Regional Science Association Congresses) we have brought out the main individual variables that influence commuting by analysing a sample of Catalan workers and their commuting decisions. Anyway, the comarcal economical structure has been analysed only at a descriptive level. Variables influencing comarcal quality of life ("amenities") have almost been ignored due to the lack of enough territorial disaggregation in the sample.

These variables are supposed to influence commuting in two different ways: A zone with a dense, well-developed economical structure will have a high density of jobs. Work demand cannot be fulfilled with resident workers, so it spills over comarcal boundaries. On the other side, this economical activity has a series of side-effects like pollution, congestion or high land prices which make these comarcas less desirable to live in. Workers who can afford it may prefer to live in less populated, less congested *comarcas*, where they can find cheaper land, larger homes and a better quality of life. The penalty of this decision is an increased commuting time. The different spatial concentration of economic sectors might also influence commuting.

Our aim in this paper is to highlight the influence of comarcal economical structure and comarcal amenities dotation in the workplace-residence location decision. A place-to place commuting model is estimated in order to find the economical and amenities variables with higher influence in commuting decisions. Data have been obtained from aggregate flow travel-matrix from the 1991 Spanish Population Census.

1.- Introduction

Commuting consists in the fact that an important fraction of workers in developed countries do not reside close to their workplaces but at long distances from them, so they have to travel to their jobs and then back home daily.

Catalonia (a Spanish region) is divided in 41 *comarcas* or small aggregations of municipalities (smaller than NUTS-3 level)[1]. Some of them have a positive commuting balance, attracting many workers from other *comarcas* and providing local jobs for almost all their resident workers. On the other side, other *comarcas* seem to be mostly residential, so an important fraction of their resident workers hold jobs in other *comarcas*.

Which variables influence the *comarca*'s role as an attraction pole or a residential zone? In previous papers (Artís, Romaní and Suriñach, 1996, 1997, 1998) we have brought out the main individual variables that influence commuting by analysing a sample of Catalan workers and their commuting decisions. Anyway, the territorial economical structure has been analysed only at a descriptive level. Variables influencing territorial quality of life ("amenities") have almost been ignored due to the lack of enough territorial disaggregation in the sample.

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2.- The standard urban model: for and against

The *Theory of residential location* is the most widely extended theory in the study of commuting. It explains why workers choose and prefer some places to reside respect to the rest of places. Its base is the *monocentrical model* (Alonso, 1964) and it suggests that workers have to choose between shorter commuting time and cheaper land prices for their homes. Land closer to the centre (where we suppose all jobs located) has a shorter commuting time associated with it, which makes it more desirable and demanded, and so it will be divided in small lots with higher prices. As we move away from the centre the size of lots increases while price per unit of land decreases (*density gradient*).

Later contributions by Mills, Muth and other authors (see Simpson, 1992) allow a more realistic version of the monocentrical model. For example, Muth allows workers to have different wages. Hekman (1985) extends Muth's model by adding time constraints, while White's (1988) version of the model allows the decentralisation of jobs. White's model is still monocentric in the sense that commuters are restricted to follow the periphery $\rightarrow$ centre direction.

Alonso's model has been a milestone in the urban studies field. It has been used for such different purposes as studying the structure of cities, housing prices or commuting. Alonso's seminal model has spawn many derivatives, refining the original and relaxing its original assumptions, in order to bring them closer to reality. Anyway, these models, like Mill's, Muth's, Hekman's or White's are still closely based on Alonso's.

In spite of their wide diffusion, monocentrical models have been criticised and ruled out by some researchers because of their apparent lack of realism. Some empirical studies, like Hamilton's (see Simpson, 1992) have casted doubts on the monocentrical model, and alternative models have been proposed. Many of these "new" urban models try to formulate a general scheme, which should be able to include the monocentrical model as a particular case. In this spirit, we should mention "port-city" models (Koide's (1990), or Zheng's (1990), for example), policentrical models or Simpson's "island" model (1992). The problem is that these models have not yet sustained the empirical testing the monocentrical model already has.

There has been some kind of confusion among researchers when testing the monocentrical model. We could divide this model's conclusions in two different groups:

a) The main hindsights about city structure and workers' and families behaviour. These include the land-accessibility trade-off, and the effect of income, transportation costs and land prices on commuting.

b) A series of simplifying assumptions which had the mission of keeping the model algebraically tractable, so that testable hypothesis could be deducted from it. We could include here mainly the concentration of all jobs in a single point (*central business district*), but also the homogeneity of workers, firms and land, or the absence of moving-home costs (which additionally, rules out reverse commuting).

It is obvious that a model is always a simplification of reality. It is forced to lose a great deal of the real world's complexity and diversity in order to be able to extract general rules. So we can conclude that the simplifying assumptions mentioned in b) are necessary if the monocentrical model pretends to be mathematically tractable (Herrin and Kern, 1992).

The problem has been that many researchers have not cared for the different nature of a) and b) premises, and when empirically testing the monocentrical model, they have rejected it on the grounds that these simplifying assumptions listed in b) do not hold in real cities.

Our aim in this paper is to perform a different kind of testing on the monocentrical model: we will relax its more restrictive assumptions in order to adapt the model to the Catalan case. Then we will formulate an econometric model for Catalonia. Our estimates will show whether the monocentrical model's most important findings hold for Catalonia or not[2].

3.- A descriptive study of commuting in Catalonia

A territorial study of commuting in Catalonia shows us that it is clearly not a monocentrical region in the sense that all jobs are concentrated in just one place: even though Barcelonès *comarca* alone concentrated 43% of Catalan jobs in 1991: even in Baix Llobregat, the *comarca* with higher out-commuting ratio, 63% of resident workers held jobs inside the *comarca*. In fact, only 16,5% of Catalan workers commuted outside their residence *comarca*, while another 20% lived and worked in different municipalities inside the same *comarca*. Most of this commuting takes the periphery → centre direction, but there is also a substantial amount of reverse-commuting: for example, about

100000 workers living in Barcelonès *comarca* out-commute to other *comarcas* (12,5% of resident workers in the *comarca*).

We have calculated several representative indexes of commuting, like the *percentage of intercomarcal commuting* (% of workers who live and work in different *comarcas*), *percentage of intracomarcal commuting* (% of workers who live and work in the same *comarca*, but not in the same municipality), an *aperture index* (for each *comarca*, the fraction of resident workers who work outside plus the workers from outside the comarca that commute in it, measured respect the total of workers living in the *comarca*) and the *perificity index* (both with and without mobility, with the purpose of seeing if commuting traduces into higher economical concentration or the other way round (Keeble *et al*, 1988)). The most important conclusions are:

The *sectorial* study (see table 1) of commuting confirms that this phenomenon does not appear uniformly in all sectors: Industry is the sector with higher commuting (specially in the capital and heavy industry branches), followed by Energy, Construction, Services and Agriculture. Generally speaking, mobility in a sector is positively correlated with the mean size of firms in the sector. This result holds when we disaggregate sectors in more specialised sub-branches. All these facts were already present in 1986, but commuting has increased heavily in all branches, specially in Agriculture, Mining and Construction. The first results published from the 1996 census indicate that these trends have persisted in the last years.

In the *territorial* side (see table 2), commuting goes from the *comarcas* surrounding the province capitals to the province capitals (Barcelonès, Gironès, Segrià and Tarragonès). Northern mountain *comarcas* (Alt Urgell, Alta Ribagorça, Cerdanya, Pallars Jussà, Pallars Sobirà, Ripollès and Vall d'Aran) present the least aperture to exterior (mostly due to communication difficulties and low population density), while inner industrial *comarcas* (Anoia, Bages, Berguedà, Osona and Ripollès) with an homogeneous urban network and a long tradition in light industry have the highest proportion of internal commuting. As we move west, away from the coastal strip, commuting decreases, Lleida being the main exception. In 1986 commuting fluxes had the same direction, but in the 1986-1991 period, commuting and aperture have increased in all *comarcas* except Cerdanya. This increase is specially important in some rural *comarcas* like Garrigues, Priorat or Terra Alta, which in 1986 were strongly isolated. This fact seems to prove that small and closed comarcal labour markets are becoming a part of larger and more integrated labour markets.

Comarcas with higher intracomarcal commuting (see table 2) are those with an homogeneous urban network, without any city undertaking an overwhelmingly dominant role, while *comarcas* with lower intracomarcal commuting either have a city that takes the leading role (like Barcelona in the Barcelonès *comarca*) or are too scarcely populated to generate scale or scope economies that might keep resident workers inside the *comarca* (like most inner agricultural *comarcas*).

We have to mention slight differences between the province capitals: while the *comarcas* of Girona, Lleida and Tarragona show an equilibrium between industry, construction and services, the *comarca* of Barcelona attracts a great fraction of the services workers living in its surroundings while it sends there a great part of its industrial workers (which means that Barcelona is mostly specialised in services, while the *comarcas* surrounding it are mostly industrial). Another differential fact is the high internal commuting in the Girona *comarca*, while the other three capitals have under-average internal commuting.

Another important fact is that in the 1986-1991 period, population living in Barcelona has decreased, but population working there has not. This means that workers prefer to reside in the *comarcas* surrounding Barcelona (mostly due to the lack of available residential land an high prices in Barcelona) though they keep their jobs in Barcelona. This phenomenon (known as *suburbanization*) is common to most large cities in developed economies. First data for the 1991-1996 period show that this trend has held.

If we study *professional categories* (see table 3), their evolution between 1986 and 1991 shows a decrease in the proportion of farmers, blue-collars and directives, while the categories of professionals, clerical, salespeople and service workers have increased their importance. Generally speaking, workers in these categories commute to the province capitals from the surrounding *comarcas*. The directive and the professional have a high degree of intercomarcal commuting; clerical workers have it slightly above average and the rest of categories show below-average intercomarcal commuting. Both the directive and professional show also a noticeable proportion of long-distance commuting (which can be due to some of them being censed in their second homes outside the city for tax reasons). Blue-collars (specially, those residing in most industrial zones) are the category with higher intra-comarcal commuting, while farmers, salespeople and service workers have the lower commuting rates, due to the small size of firms in these sectors. The military (only 0.22% of workers in Catalonia) have also a low commuting rate, because most of them live in the barracks or in army houses close to them.

The main effect of commuting is an increase of the economical concentration of Catalonia in the coastal plain, specially in Barcelona Metropolitan Area. This fact increases the territorial disequilibrium of Catalan economy. We have to bear in mind, though, that the alternative to commuting would be large population moves from the inner plains into the metropolitan *comarcas*, which would leave most of the interior of Catalonia unpopulated.

4.- A place to place model for commuting in Catalonia

Our aim is to estimate inter-*comarca* commuting in Catalonia. Our explicative variables should cast light on the attributes that make a *comarca* a preferred destination for workers, or either, the characteristics that make it a better residential choice.

The selected functional form has been the logistic curve: if we use each pair of *comarcas* as a case, we can use the ratio:

$$c_{ij} = \frac{\text{Number of i} \rightarrow \text{j commuters}}{\text{Total workers living in i}}$$

as our dependent variable. This variable will take always a value between 0 and 1, as it is the sum of n individual choices made by workers living in the origin *comarca*: each individual choice will take a value of 1 if the worker decides to commute between i and j and it will equal 0 otherwise. Our aggregate variable c_{ij} will equal 1 if all workers living in *comarca* i out-commute to j. $C_{ij} = 0$ if there is no commuting between i and j, and $0 < c_{ij} < 1$ for any amount of realistic commuting between i and j. A grouped data logit model is an adequate specification for such data.

The explicative variables should be able to capture different features from origin (i) and destination (j) *comarcas*: first, we should consider amenities, or variables that make i an attractive place to live. Then we should consider labour market variables from j, as they will explain j's capacity to attract workers from i. This specification has been used by Merriman and Hellerstein (1994) in a study of commuting in Tokyo.

Anyway, we have seen in section 3 that some workers live in j, while most of the resident workers in i do not commute outside the *comarca* where they live, so the model commented above would arise two important questions:

a) Why does a worker decide to commute if s/he might be able to find a job in his/her residence *comarca*?
b) Once the worker has found a job in a different comarca: why does he keep on commuting instead of moving to the comarca where he actually works?

An intuitive answer to these questions would be: "He commutes because the destination labour market is more attractive than origin's. And he does not move because living conditions are better in his residence *comarca*."

This would force us to reformulate our first model: now the worker compares the labour market and living conditions of both areas before making his choice. So now we have four sets of explicative variables, which are:

L_i: labour market conditions in the residence *comarca*.
L_j: labour market conditions in the destination *comarca*
H_i: quality of life conditions in the origin *comarca*.
H_j: quality of life conditions in the destination *comarca*.

How do we include these four sets of variables in our model? An obvious choice would be the following:

$$c_{ij} = \beta_0 + \beta_1 L_i + \beta_2 L_j + \beta_3 H_i + \beta_4 H_j + u_{ij} \qquad (1)$$

In this model we could reasonably expect that $\beta_1 \neq \beta_2$ and $\beta_3 \neq \beta_4$. This means that the same variables would have different effect if they belong to the origin or destination *comarca*. According to Gabriel *et al* (1993), this would mean that workers have a different level of information about each zone. This could be accepted in a migration model, where the individuals are moving over long distances (like Gabriel *et al* (1993a, 1993b)), but would be less realistic in a region like Catalonia, specially if the worker travels daily between both *comarcas*. Therefore, we suppose that workers

have the same information about origin and destination *comarcas*, so they only have to compare the variables. Thus, our model would have the following form:

$$c_{ij} = \beta_0 + \beta_1 (L_j / L_i) + \beta_2 (H_j / H_i) + \beta_3 A_{ij} + u_{ij} , \qquad (2)$$

where A_{ij} is a vector of variables that measures the accessibility level (ease or difficulty of commuting) between *comarcas* i and j.

4.1.- The H vector should include variables related to quality of life in *comarcas*. Alonso's model gives us two obvious choices to include: housing prices and home sizes. We should also consider other amenities that could influence residential decisions: some authors have tried to use a full set of amenity variables, including climatic, cultural, crime and urban structure variables. If correctly specified, this approach is appealing because these variables could inform us about what families are looking for when choosing a place to live, but it also brings out some important problems:

* If we want to capture all the different kinds of amenities, we need a large set of variables. This decreases the degrees of freedom in the model.
* Variables are likely to be correlated, therefore causing multicollinearity problems.
* The election of amenity variables is always somewhat arbitrary (see Knapp and Graves, 1989).

Other studies have tried to capture the effect of amenities using only one or two relevant variables, but this strategy is bound to cause a substantial loss of information in the model.

We have decided for a third option: using a quality of life index that can sintethyse most of the amenities information without causing multicollinearity. The chosen index is the **Sintethic quality of life index for Catalan *comarcas*** (Quadrado, 1996). This index aggregates information about climate, environment, culture, infrastructures and climate into a single variable (see table 4). It has the additional advantage (for our purposes) of not including information about home prices or home sizes, so these two variables can enter separately into our model.

Our main problem has been the lack of information about housing prices: no official source calculates this information for the 41 Catalan *comarcas*. The only information available is a study ordered by "Departament de Política Territorial i Obres Públiques" (Infrastructures Department of Catalan regional government), which calculates home prices (per m^2) for 25 cities in 19 *comarcas*

(see table 4). As these 19 *comarcas* account for 87% of total inter-*comarca* commuting, we have dropped the rest from our model. Thus, our model has 342 cases, each being a pair of the 19 *comarcas* for which we have information about home prices[3] (see map 1).

Another important variable is the availability of residential land and housing. We have proxied it by measuring the proportion of large homes (> 150m^2) in the *comarca*. Some families (described by Simpson as "land-hungry") may be able to buy a home in "central" comarcas, in spite of higher prices there. Nevertheless, they value residential space over accessibility, so they may prefer to buy a larger home away from the centre and commute.

The last variable included in the H vector is the migration balance (in percentage of total resident population), as *comarcas* with a better quality of life are supposed to attract migrants from other zones. We are using a "revealed prefference" approach: we suppose that migrants move to the *comarcas* they consider more desiderable to live in.

4.2.- The L vector: This vector of variables captures labour market conditions. We must include first a wages variable: if wages are higher in some zones than the rest, workers will be tempted to quit their jobs to find new ones in zones with higher wages, provided the wage increment compensates for the increased commuting time and costs. We have used the mean collection of personal income tax (Impuesto sobre la Renta de las Personas Físicas or IRPF) for each comarca, as this tax charges mainly wages. A second obvious variable is the unemployment rate: theory leads us to expect that commuting flows have the high unemployment $\rightarrow$ low unemployment *comarcas* direction.

Lastly, there should be several variables measuring the difference in the comarcal productive structure. We have used a 7 sector disaggregation (see table 1). Then we have measured *comarcas*' specialisation in each sector as the fraction of jobs in that branch respect to the total jobs in the *comarca*. Only three sectors showed significative values, so the rest have been dropped from our model. We tried a simmilar approach for the professional cathegories, but the results were inconsistent and are not shown here.

Comarcal population has been used as a proxy for agglomeration economies. We have also used a dummy variable to reflect the differential attractive effect that province capitals may have.

4.3.- The A vector: This vector measures accessibility between each pair of *comarcas*. It includes distance, a dummy variable that equals 1 if the two *comarcas* have a common boundary and three dummy variables that equal 1 if the *comarcas* are connected by *metro* (tube), *RENFE* (shuttle services of national railways) or *Ferrocarrils de la Generalitat* (regional railways). Merriman and Hellerstein (1994) and Crampton (1990) outline the importance of rail transport for commuting flows.

Our model will take the following functional form:

$$C_{ij} = \alpha_0 + \beta_1 \text{ Quality of Life} + \beta_2 \text{ Net migration} + \beta_3 \text{ Price } m^2 + \beta_4 \text{ Homes} > 150 + \delta_1 \text{ Unemployment} + \delta_2 \text{ \% Agriculture} + \delta_3 \text{ \%Cap Ind} + \delta_4 \text{ \% Sal ser} + \delta_5 \text{ Inc Tax} + \delta_6 \text{ Population} + \delta_7 \text{ Capital} + \gamma_1 \text{ Distance} + \gamma_2 \text{ Contact} + \gamma_3 \text{ Nat Rail} + \gamma_4 \text{ Tube} + \gamma_5 \text{ Reg Rail} + u_{ij} \quad (3)$$

where:

Quality of Life = Quality of Life_j / Quality of Life_i
Net migration = Net migration_j / Net migration_i
Price m^2 = Housing price_j / Housing price_i
Homes > 150 = % Homes > $150m^2{}_j$ / (% Homes > $150m^2{}_i$
Unemployment = % Unemployment_j / % Unemployment_i
% Agriculture = % Agriculture_j / % Agriculture_i
%Cap Ind = % Heavy industry_j / % Heavy industry_i
% Sal ser = % Saleable services_j / % Saleable services_i
Inc Tax = Average pesonal income tax_j / Average personal income tax_i
Population = Population_j / Population_i
Capital = *Dummy* for commuting to and from province capitals
Distance = Distance between *comarcas*
Contact = *Dummy* for pairs of *comarcas* sharing boundaries
Nat Rail = *Dummy* for pairs of *comarcas* connected by shuttle services of national railway
Tube = *Dummy* for pairs of *comarcas* connected by tube
Reg Rail = *Dummy* for pairs of *comarcas* connected by regional railway.

5.- Results of the model

Table 5 shows the main results of the logit model. A good fit, with an adjusted R^2 of 0,91 is obtained, while no important correlationship between independent variables has been detected.

The main results (with variables grouped in vectors H, L and A) are the following:

* **Quality of life** (= Quality of Life Index in destination / Q.L.I in origin): This variable has a negative and highly significative coefficient. Workers are willing to spend more time commuting in exchange for the amenities they can find in their residence *comarcas*.

* **Net migration** (= Net migration (in % of resident population) in destination / Net migration (in % of resident population) in origin). This variable has also a negative sign, meaning that workers are leaving central *comarcas* (those with higher jobs density and positive commuting balance) to live in more residential *comarcas*, but not changing their workplaces. Central comarcas are usually more crowded and expensive.

* **Price_m^2** (=Average housing price per m^2 in origin / Average housing price per m^2 in destination). We can expect that comarcas with a higher job density are more crowded. Housing faces a strong competition from alternative uses of land, like industrial, commercial and business. Both facts increase housing prices respect the rest of *comarcas*, as deduced from the Residential Location model. Our estimates confirm the model's predictions: This variable has a positive sign, suggesting that workers prefer to live in *comarcas* where they can find cheaper homes, even if it forces them to longer commutes.

* **Homes>150** (= % of homes larger than 150 m^2 in destination / % of homes larger than 150 m^2 in origin). This variable proxies the mean size of homes in each *comarca*. Central *comarcas*, with a high density of jobs, tend to present congestion problems and scarcity of residential land, as it has to compete with other land uses. Alonso's model predicts that the mean size of homes will decrease as we approach the central business district, forming a density gradient. Our estimates confirm this prediction: commuting takes the larger homes $\rightarrow$ smaller homes *comarcas* direction. We could even separate families in "access-hungry", who place a high value in their time and prefer to live in smaller homes, closer to their jobs and "land-hungry", who are willing to spend more time commuting in exchange for having a larger home (Simpson, 1992). "Land-hungry" households are more likely to be affected by this variable.

* **Unemployment** (= % unemployment in destination / % unemployment in origin). Surprisingly, the estimated coefficient of this variable is positive, meaning that workers tend to commute to comarcas with high unemployment rates. There are three possible explanations for this finding, which slightly resembles the "Harris-Todaro paradox" (1970):

1) *Comarcas* with higher unemployment also have above-average wages. The attractive effect of wages could be stronger than the dissuasive effect of unemployment.

2) Commuting is measured only for employed workers, so the unemployment in the destination zone does not affect them (as they are already employed). Their situation is far different from a migrant's, who usually moves first and then seeks a job. We could say that migrants give more importance to this variable, as they face a higher level of uncertainty than commuters.

3) *Comarcas* with higher unemployment rates are also the ones with larger labour markets.

* **%_agriculture** (= % of jobs in the agriculture in destination / % of jobs in the agriculture in origin). This variable measures the relative agricultural specialisation of both *comarcas*. As agriculture is the sector with a lower commuting rate, this variable shows a negative coefficient, meaning that *comarcas* specialised in agriculture are not an attractive destination for commuters.

* **%_cap_ind** (= % of jobs in the capital and intermediate goods industry in destination / % of jobs in the capital and intermediate goods industry in origin). Branches in this sector have the highest commuting rates in Catalonia. Their factories are usually large, so their labour demand spills over comarcal boundaries. This variable is positive and highly significant, meaning that commuters are attracted by *comarcas* with a strong specialisation in this sector.

* **%_sal_ser** (= % of jobs in the saleable services sector in destination / % of jobs in the saleable services sector in origin). As this sector tends to be formed by small firms (restaurants, garages or retail shops as an example), it has below-average commuting rates. *Comarcas* specialised in it should have, *ceteris paribus*, lower attractive power for workers. The negative sign on the estimated coefficient confirms this hypothesis.

Results for **%_agriculture**, **%_cap_ind** and **%_sal_ser** variables are coherent with the descriptive analysis in section 3.

* **IRPF** (= Average IRPF tax collection in destination / average IRPF tax collection in origin). The standard residential location model postulates that firms located at the central business district have to pay higher wages than decentralised firms. If they did not, workers could increase their utility by seeking a job in a firm closer to their home. Firms in the central business district have to compensate their workers for their longer commutes. If the model holds, this variable should have a positive sign and a large explanatory power in our equation.

  Our results confirm the prediction: this variable (a proxy for average wages) is positive and highly significant. Thus, workers are willing to commute to *comarcas* with higher wages.

* **Population** (= Population in destination / population in origin). This variable is meant to capture agglomeration economies: if firms locate in the most populated areas they have access to large consumer and labour markets, as well as lowering their transport costs. On the other side, it can act as a congestion disamenity for workers and families. Both effects reinforce each other, so the population variable has a positive sign in our commuting equation.

* **Capital:** This is a dummy variable that can take the following values:
  1 if the destination *comarca* contains a provincial capital and the origin comarca does not.
  0 If none of the two *comarcas* contains a province capital.
  -1 if the commuting flow goes from a capital to a non-capital *comarca* (Gabriel *et al*, 1993).

  We have included this variable as a test of the extra attractive power of provincial capitals respect the rest of *comarcas* in Catalonia. Its coefficient is positive and significative, meaning that province capitals have an extra attractive power for commuters, probably due to the concentration of national and regional governments' institutions in them. Its correlation with the Non-saleable services branch (not included in the model) is very high.

* **The accessibility (A) vector**: This vector contains a set of variables used to measure the feasibility or difficulty of commuting between each pair of *comarcas*. We should expect that better communications and shorter travel times result in higher commuting flows. The ideal variable would have been average commuting time between *comarcas*, but unfortunately it is not available, so we have had to use other variables to proxy it.

The most important is **distance**: as expected, it has a negative coefficient and it is the highest significance variable in our model. its sign is reinforced by the positive coefficient of the **contact** variable (a dummy that takes a value of 1 if both *comarcas* share boundaries and 0 otherwise). We have also included three dummy variables to control for the presence of rail transport between *comarcas*: **Nat Rail** (shuttle local services of national rail or *RENFE*), **Reg Rail** (regional railway or *Ferrocarrils de la Generalitat*) and **Tube** (*Metro*). All three are positive and significative. Railway travel times are not affected by congestion (although travellers' confort is), unlike bus or private car. That's why rail (when available) is the natural choice for commuters, specially when travelling in peak hours.

5.- Conclusions and future research lines

We set out to analyse commuting in Catalonia and try to validate (or reject) for this region the most important predictions of the standard residential location model.

Even though population in Catalonia is highly centralised (Barcelonès and the four *comarcas* that surround it account for two thirds of Catalan population), and 63% of Catalan workers do not commute away form their residence municipality, there is a trend towards the increase of both suburbanization and commuting times.

Workers who decide to commute are willing to accept a loss of utility (in the form of longer commutes), in exchange for a better quality of life and larger, cheaper homes. Some workers are attracted by higher wages in other *comarcas*, but they do not wish to change their residence *comarca*. All these facts are predicted in the standard urban model, so Catalan workers' and families' behaviour is well reflected in this model.

We have also shown that commuting does not appear homogeneously: it concentrates in certain zones, activity branches (those with larger firms and factories) and professional categories (mostly, directives and professionals).

A possible extension of the model would be to disaggregate the quality of life index into several sub-indexes, each one reflecting a different side of the quality of life. This would have the

advantage of improving information about families' preferences on residential choice with little increase of multicollinearity. As data from the 1996 Population Census become available, the model could be re-estimated to asses the stability of commuting flows and workers' preferences. It would also be useful to obtain data about residential land prices for all Catalan *comarcas*, but unfortunately, this is not likely to happen in the short term.

NOTES

[1] We are using *comarcas* as main territorial unit. Our study will concentrate in inter-*comarca* (intermediate and long-range) commuting, with only a brief comment on intra-*comarca* (short range) commuting.

[2] Herrin and Kern choose a different way of testing the standard urban model: they kept in their sample only the workers and families who adijusted to the model's main restrictions and supressed the rest.

[3] As the 19 comarcas chosen are the most urbanised and populated, our model will not capture the effects of rural inter-comarcal commuting. For example, we have seen in section 3 that the Energy sector is one of the branches with higher commuting rates. But this branch is mainly concentrated in non-urban *comarcas*, so it does not appear as an explicative variable in our model.

APPENDIX: TABLES AND RESULTS

TABLE 1: SECTORIAL 24-BRANCHES CLASSIFICATION

8-BRANCH	24-BRANCH	% COMMUTING (*)	BRANCH NAME
Agriculture	Sector 1	8,9	Agriculture, cattle and silviculture
	Sector 2	7,8	Fishing
Energy	Sector 3	26,1	Petroleum, natural gas and radio-active minerals
	Sector 4	18,1	Electricity, gas and water
Capital & Intermediate goods industry	Sector 5	22,5	Extraction and transformation of minerals
	Sector 6	22,7	Chemical Industry
	Sector 7	22,2	Metal, machinery and electrical supplies
	Sector 8	26,4	Transportation Material
Consummer goods industry	Sector 9	17,0	Food, Beverage and Tobacco
	Sector 10	14,5	Textile, confection and leather
	Sector 11	15,4	Wood and furniture
	Sector 12	19,9	Paper, printing and book editing
	Sector 13	21,4	Gum, plastics and other manufactured products
Construction	Sector 14	17,5	Construction and civil engineering
Saleable services	Sector 15	13,8	Retail and repair
	Sector 16	12,4	Restaurants, cafés and hotel trade
	Sector 17	18,1	Transportation
	Sector 18	16,2	Communications
	Sector 19	13,5	Finance and insurance
	Sector 20	15,3	Services for firms
Non-saleable services	Sector 21	13,9	Civil services, defence and social security
	Sector 22	17,1	Education, research and culture
	Sector 23	15,5	Health and social assistance
	Sector 24	15,0	Other services
	CATALONIA	16,7	Catalan average

(*) % of workers in the branch who live and work in different *comarcas.*

TABLE 2: MAIN COMARCAL COMMUTING RATIOS (1991)

Comarca:	Resident working population	Commuting balance (%)	Aperture Index	Intercomarcal commuting (%)	Intracomarcal commuting (%)
Alt Camp (AC)	13371	4,53	28,52	11,99	13,31
Alt Empordà (AE)	34176	-2,42	11,24	6,83	24,67
Alt Penedès (AP)	26982	1,26	25,62	12,18	25,31
Alt Urgell (AU)	7053	-5,83	14,49	10,16	11,44
Alta Ribagorça (AR)	1057	-16,04	23,19	19,62	7,55
Anoia (An)	30468	-3,10	15,88	9,49	31,54
Bages (Bg)	53051	-4,63	14,49	9,56	24,76
Baix Camp (BC)	41563	-11,42	30,75	21,08	10,15
Baix Ebre (BEb)	22148	-1,72	18,72	10,22	16,29
Baix Empordà (BE)	32846	-3,93	15,18	9,56	22,13
Baix Llobregat (BL)	190936	-14,06	61,09	37,58	22,54
Baix Penedès (BP)	13082	-6,82	32,59	19,70	18,58
Barcelonès (BA) (*)	904088	5,68	30,72	12,52	17,29
Berguedà (Be)	12892	-4,84	19,19	12,01	19,89
Cerdanya (Ce)	4795	-2,90	16,10	9,50	12,80
Conca de Barberà (CB)	5856	-10,39	25,60	18,00	10,86
Garraf (Ga)	24765	-9,00	26,73	17,86	16,69
Garrigues (Gg)	5689	-16,61	28,16	22,38	6,19
Garrotxa (Gt)	18271	-2,96	11,85	7,40	20,30
Gironès (Gi) (*)	55183	6,95	25,65	9,35	29,00
Maresme (Ma)	91633	-15,39	31,50	23,45	18,80
Montsià (Mo)	17784	-6,56	18,48	12,52	9,03
Noguera (No)	10950	-12,10	23,84	17,97	10,02
Osona (Os)	48434	-1,76	11,87	6,82	30,96
Pallars Jussà (PJ)	4380	-4,49	21,63	13,06	12,89
Pallars Sobirà (PS)	1817	-12,85	23,41	18,13	11,89
Pla d'Urgell (PU)	10209	-2,42	28,38	15,40	15,42
Pla de l'Estany (PE)	7975	-5,40	30,19	17,79	27,22
Priorat (Pr)	2744	-16,97	29,02	23,00	8,56
Ribera d'Ebre (RE)	7469	-1,10	25,30	13,20	20,72
Ripollès (Ri)	10333	-5,70	16,00	10,85	16,80
Segarra (Se)	7096	7,71	36,28	14,28	12,05
Segrià (Sgà) (*)	60161	-0,02	12,16	6,09	10,89
Selva (Sl)	37043	-2,21	28,92	15,57	15,33
Solsonès (So)	4090	-3,65	18,96	11,31	11,10
Tarragonès (Ta) (*)	60448	6,81	31,44	12,32	15,47
Terra Alta (TA)	3922	-12,73	17,22	14,98	4,98
Urgell (Ur)	10238	-9,11	28,64	18,87	8,88
Vall d'Aran (VA)	2699	2,27	15,01	6,37	15,46
Vallès Occidental (VOc)	240223	1,17	40,10	19,47	21,39
Vallès Oriental (VOr)	108760	6,15	43,87	18,86	31,59
Catalonian average (TOT)	2246680		24,58	16,32	19,52

Commuting balance= (Workers who commute into the *comarca* - resident workers who work outside) / Resident workers

Aperture Index= (Workers who commute into the *comarca* + resident workers who work outside) / Resident workers

Intercomarcal commuting = Resident workers who commute outside the *comarca* / Resident workers

Intracomarcal commuting= Resident workers who commute to another municipality in the same *comarca* / Resident workers

(*): These *comarcas* contain the province capitals.

TABLE 3: COMMUTING AND PROFESSIONAL CATEGORIES (1991)

CATEGORY	WORKERS 1991	% INTERCOMARCAL COMMUTING 1991	% INTRACOMARCAL COMMUTING, 1991
Professional	296738 (13,16%)	22,63%	15,88%
Directive	54332 (2,41%)	23,34%	14,01%
Clerical	366364 (16,24%)	16,55%	18,13%
Sales	303748 (13,47%)	14,26%	14,19%
Services	234042 (10,38%)	13,08%	17,77%
Farmers	82154 (3,64%)	5,99%	10,61%
Blue-collars	913028 (40,48%)	16,19%	24,69%
Military	5024 (0,22%)	14,15%	11,11%

TABLE 4: RESIDENTIAL PRICES PER M^2 (1991)

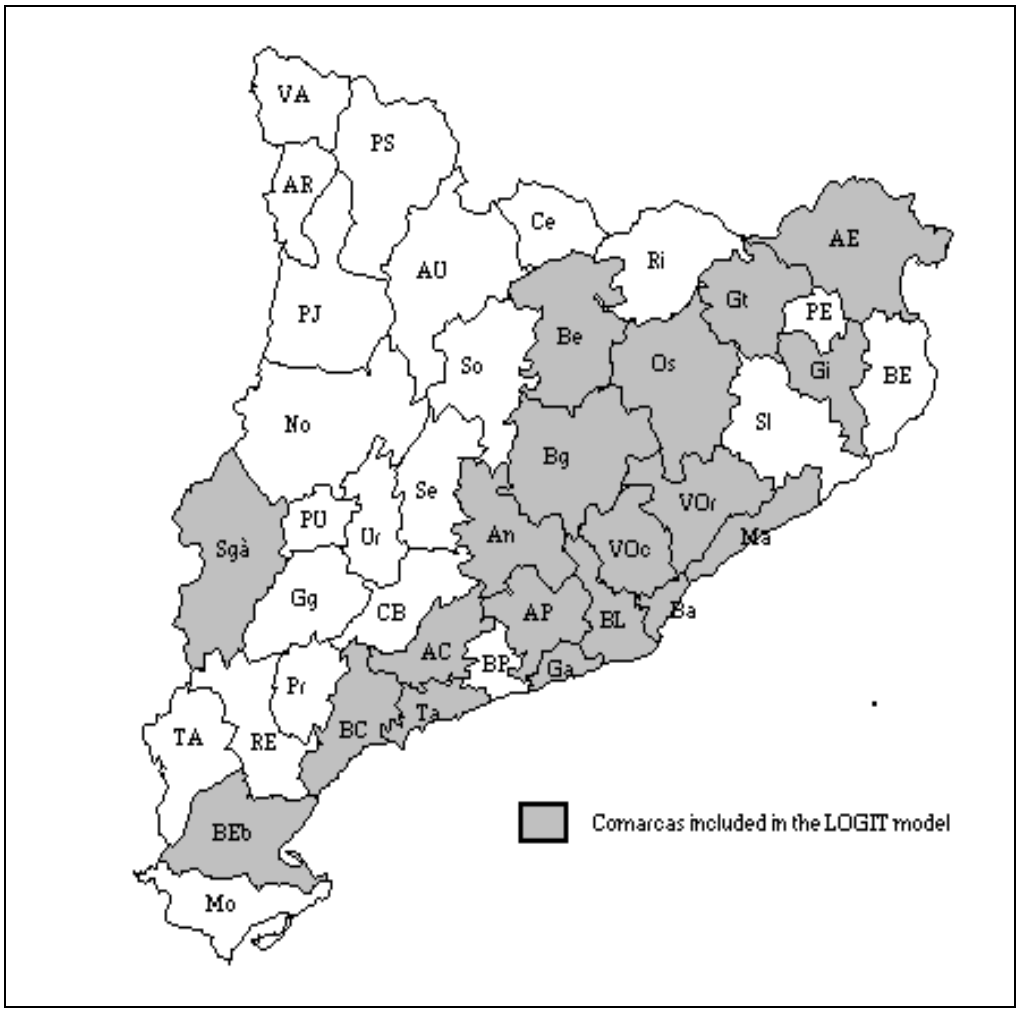
COMARCA	QUAL. OF LIFE INDEX (*)	MUNICIPALITY	POPULATION	PRICE PER M^2
Barcelonès	107.3	Barcelona	1643452	210925
		L'Hospitalet de Ll.	272578	141947
		Badalona	218725	127190
Tarragonès	105.6	Tarragona	110153	109651
Gironès	122.2	Girona	68696	113937
Segrià	101.1	Lleida	112093	95265
Vallès Occidental	94.5	Sant Cugat	38937	211614
		Cerdanyola	56612	143036
		Sabadell	189404	136445
		Terrassa	158063	114146
Vallès Oriental	88.3	Granollers	51873	121910
Baix Llobregat	90.1	Sant Just Desvern	12471	235642
		Martorell	16653	104576
Maresme	94.9	Mataró	101510	133576
Garraf	90.9	Vilanova i la Geltrú	45864	124999
Alt Penedès	109.5	Vilafranca	27818	95590
Bages	97.6	Manresa	66320	103202
Osona	105.7	Vic	28736	102234
Anoia	106.1	Igualada	31855	98688
Berguedà	94.0	Berga	13905	85974
Alt Camp	102.1	Valls	20092	100954
Baix Camp	111.4	Reus	87670	100363
Baix Ebre	83.9	Tortosa	29452	82248
Garrotxa	97.7	Olot	26713	93368
Alt Empordà	96.2	Figueres	34573	93008

(*) Catalan average = 100

TABLE 5 LOGIT MODEL ESTIMATES

VARIABLE	COEFFICIENT	STANDARD ERROR	T-RATIO
Quality of life	-0.437	0.040	10.925
Net migration	-0.131	0.002	65.50
Price_m^2	0.131	0.001	131.45
Homes>150	-0.007	0.000	135.74
Unemployment	0.533	0.016	33.125
%_agriculture	-0.069	0.001	69.43
%_cap_ind	0.302	0.008	37.75
%_sal_ser	-0.846	0.023	36.78
Inc Tax	2.947	0.057	51.70
Population	0.001	0.000	3.21
Capital	0.045	0.011	4.09
Distance	-0.036	0.000	39.73
Contact	1.024	0.010	102.41
Reg Rail	0.015	0.008	1.92
Nat Rail	0.226	0.008	28.25
Tube	0.812	0.009	90.22
Intercept	-7.353	0.068	180.44
Number of cases: 342			
Adjusted R^2: 0.91			

MAP 1: COMARCAL DIVISION OF CATALONIA AND COMARCAS USED IN THE LOGIT MODEL



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